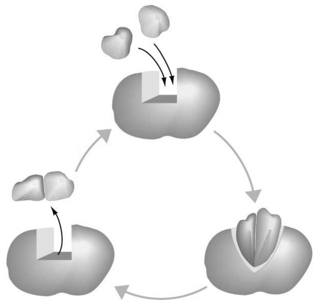
Chapter 6:
Energy Flow in the Life of a Cell



What is Energy?

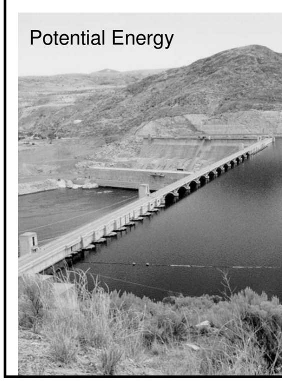
Answer: The Capacity to do Work

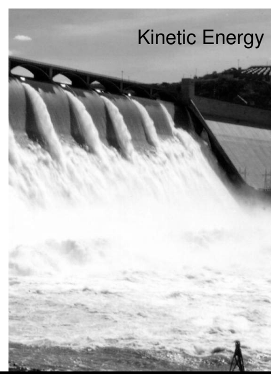
Types of Energy:

1) Kinetic Energy = Energy of movement
   - Light (movement of photons)
   - Heat (movement of particles)
   - Electricity (movement of charged particles)

2) Potential Energy = Stored energy
   - Chemical (stored in bonds)
   - Electrical (stored in battery)
   - Positional (stored in location of object)

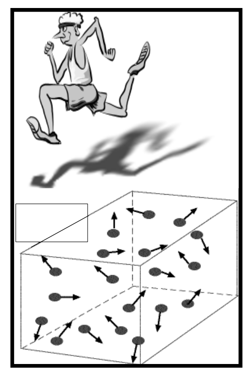
Potential energy can be converted to kinetic energy (& vice versa)



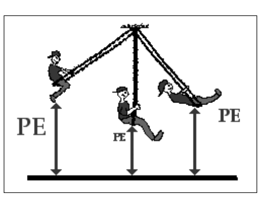


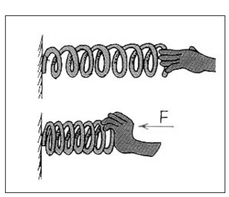
Kinetic Energy
- *Energy of motion*

Includes:
- electrical
- thermal (heat)
- others



Potential Energy
- Energy that matter possesses because of its location or structure.





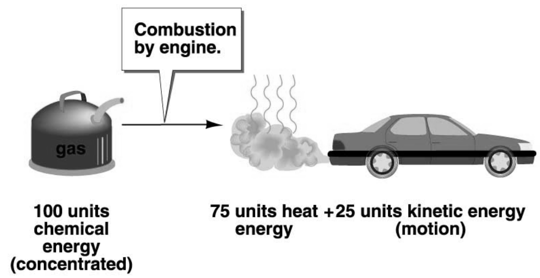
Pressing the spring down stores potential energy

Laws of Thermodynamics: Explain the properties and behavior of energy

1st Law of Thermodynamics:
- Amount of energy in universe remains constant
  - Energy is neither created or destroyed
  - Law of Conservation of Energy
- Energy can be converted (Chemical $\rightarrow$ Heat)

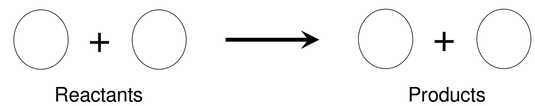
2nd Law of Thermodynamics:
- When energy converted, the amount of useful energy decreases
  - No process is 100% efficient

The Laws of Thermodynamics in Action:



Chemical Reaction:

- Process that forms and breaks chemical bonds holding molecules together

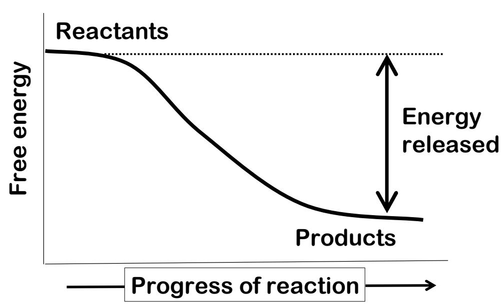


Two Types of Chemical Reactions:

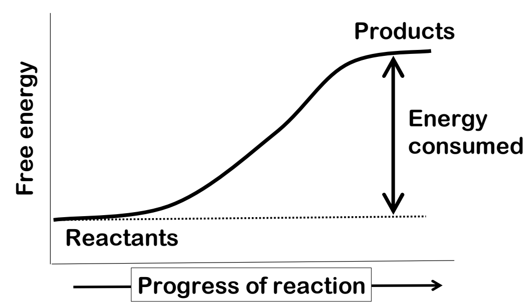
1) Exergonic = Reaction liberates energy
   Energy exits the reaction

2) Endergonic = Reaction requires energy to proceed
   Energy is consumed in

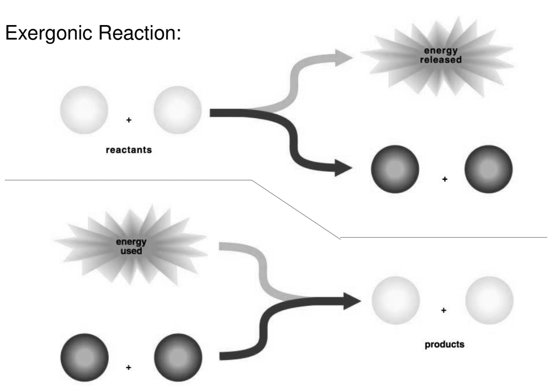
Exergonic reaction: down hill reactions



Endergonic reaction: Uphill reactions

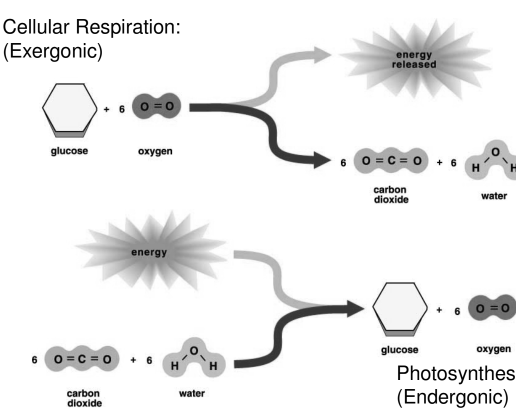


Exergonic Reaction:



Endergonic Reaction:

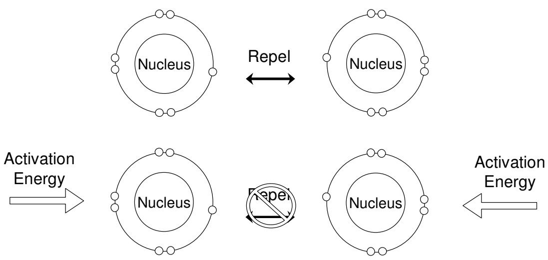
Cellular Respiration:
(Exergonic)



Photosynthesis:
(Endergonic)

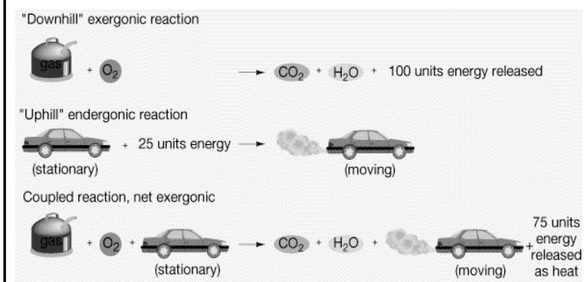
Activation Energy: Energy required to “jumpstart” a chemical reaction

- Must overcome repulsion of molecules due to negative charged electrons



Coupled Reaction:

- An exergonic reaction supplies the energy needed to drive an endergonic reaction.



Coupled Reaction:

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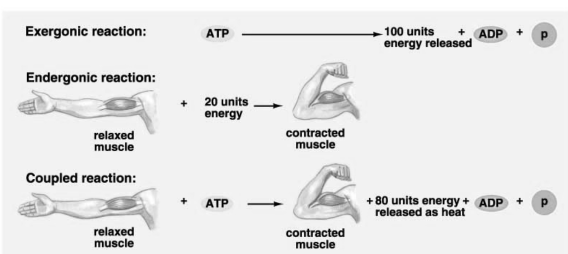


(Figure 6.3)

How is Cellular Energy Carried Between Reactions?

Answer: Energy-Carrier Molecules

Energy-Carrier Molecules:

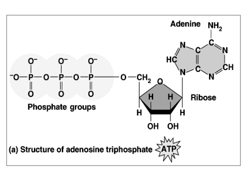
- Rechargeable Battery
- Unstable = Short-term storage
- Function within a single cell

Types:

1) Adenosine triphosphate (ATP)
   - Most common energy-carrier molecule
   - Synthesized from adenosine diphosphate (ADP)

ATP (adenosine triphosphate)

The energy source that directly powers cellular work

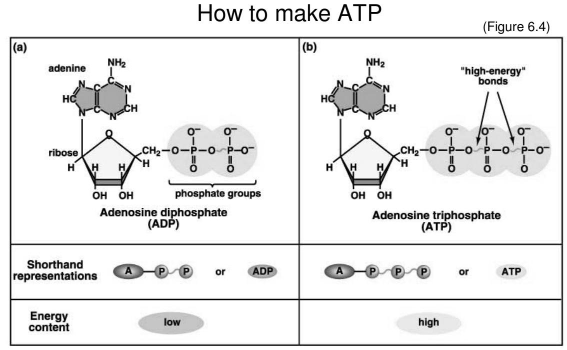


ATP hydrolysis: $\textbf{ATP} \longrightarrow \textbf{ADP} + \textbf{P}_i$

ATP regeneration: $\textbf{ADP} + \textbf{P}_i \longrightarrow \textbf{ATP}$

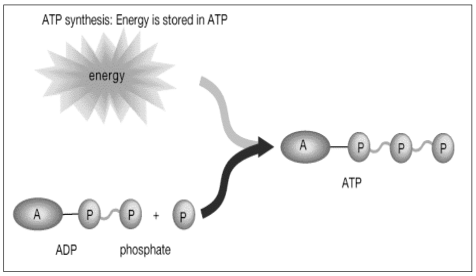
How to make ATP

(Figure 6.4)

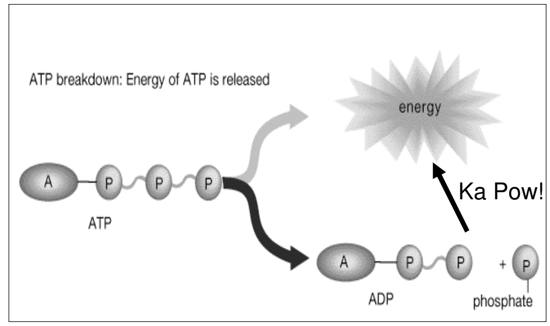


Is this an exergonic or endogonic reaction?

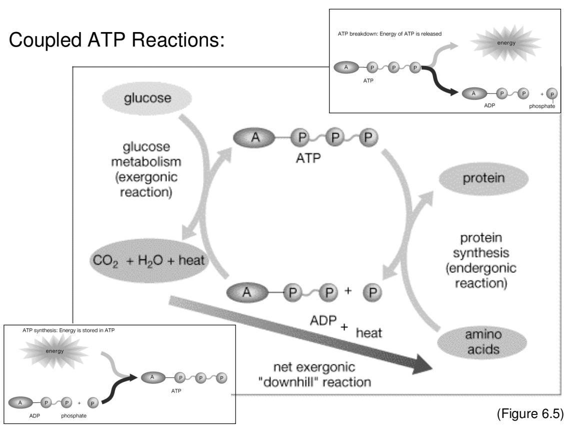
Making ATP: Endergonic



Breaking ATP: Exergonic!



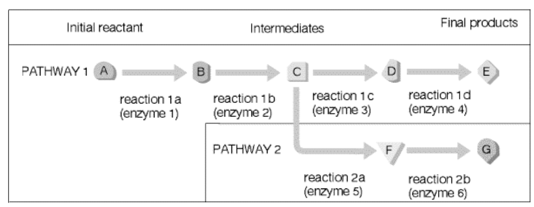
Coupled ATP Reactions:



(Figure 6.5)

Metabolism: Sum of all chemical reactions

- Reactions are linked in metabolic pathways



- Photosynthesis (Chloroplast)
- Cellular Respiration (Mitochondria)

How do Cells Regulate Metabolic Reactions?

1) Couple reactions together
2) Energy-carrier molecules
3) Enzymes

What are Enzymes?

Answer: Molecules (proteins) that catalyze chemical reactions

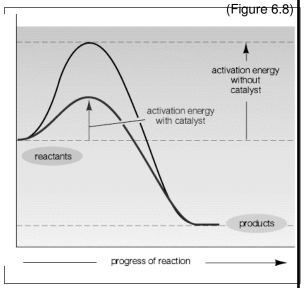
What are Catalysts?

Answer:

Molecules that speed up chemical reactions

- Lower activation energy

(Figure 6.8)

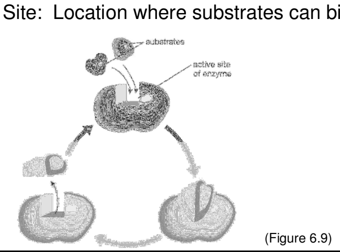


- Catalysts only speed up reactions that would occur spontaneously
- Catalysts are not destroyed in the reaction

Enzymes = Biological Catalysts

Unique Properties of Enzymes (compared to other catalysts):

1) Enzymes are specific (High Specificity)
   - Catalyze only one, or a few, chemical reactions
   - Structure Dictates Specificity:
     - Active Site: Location where substrates can bind



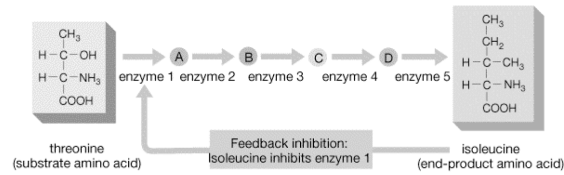
(Figure 6.9)

Enzymes = Biological Catalysts

Unique Properties of Enzymes (compared to other catalysts):

1) Enzymes are specific (High Specificity)
2) Enzyme activity is regulated:
   - A) Regulate synthesis of enzyme
   - B) Regulate active state of enzyme
     - Enzymes synthesized in inactive form and activated only when needed (*e.g.* pepsin)
   - C) Feedback Inhibition: Enzyme activity is regulated by product concentration

Feedback Inhibition:



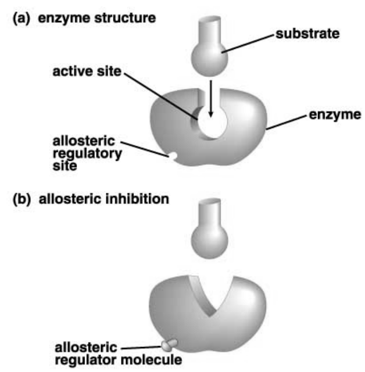
(Figure 6.10)

Enzymes = Biological Catalysts

Unique Properties of Enzymes (compared to other catalysts):

1) Enzymes are specific (High Specificity)
2) Enzyme activity is regulated:
   - A) Regulate synthesis of enzyme
   - B) Regulate active state of enzyme
   - C) Feedback Inhibition
   - D) Allosteric Regulation: Small molecules bind to enzyme, changing shape of active site

Allosteric Regulation:



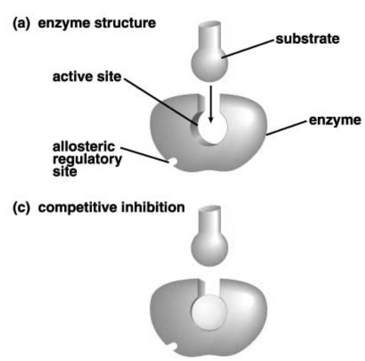
(Figure 6.11)

Enzymes = Biological Catalysts

Unique Properties of Enzymes (compared to other catalysts):

1) Enzymes are specific (High Specificity)
2) Enzyme activity is regulated:
   - A) Regulate synthesis of enzyme
   - B) Regulate active state of enzyme
   - C) Feedback Inhibition
   - D) Allosteric Regulation
   - E) Competitive Inhibition: Molecules compete for the active site of the enzyme

Competitive Inhibition:



(Figure 6.11)

The activity of enzymes are influenced by their environment:

- 3 - Dimensional structure of enzymes due to hydrogen bonding
  - Factors affecting hydrogen bonding:
    1) pH (optimal = 6 - 8)
    2) Salt Concentration
    3) Temperature
- Some enzymes require helper molecules to function
  - Co-enzymes (bind with enzyme - assist in reaction)
    - B - vitamins necessary for synthesis